

What is claimed is:

1. A digital image quality enhancing method to improve a quality of a document image comprising pixels with a predetermined resolution and obtained by scanning a script comprising a combination of a background, a text, and an image, the method comprising:

updating history information regarding color data and a pixel type of a concerned pixel using previous history information of the concerned pixel;

determining a block feature type of the concerned pixel using the pixel type and the updated history information of the concerned pixel;

determining a type of an area to which the concerned pixel belongs based on a second type of a second area to which a first neighboring pixel in a left direction of the concerned pixel belongs, a third type of a third area to which a second neighboring pixel in a line above the concerned pixel belongs, the pixel type of the concerned pixel, and the determined block feature type; and

performing different image quality enhancing processes on the concerned pixel based on the determined area type.

2. The digital image quality enhancing method of claim 1, wherein the updating of the history information comprises:

low-pass filtering (pre-processing) the concerned pixel according to a magnitude of a bimodality of the concerned pixel.

3. The digital image quality enhancing method of claim 2, wherein the pre-processing of the concerned pixel comprises:

calculating the bimodality of the concerned pixel;

comparing the bimodality with a predetermined threshold; and

when the bimodality is less than the predetermined threshold in the bimodality comparison, performing the low pass filtering.

4. The digital image quality enhancing method of claim 3, wherein the calculation of the bimodality comprises:

calculating a mean of brightness components of all pixels in a window of a predetermined size around the concerned pixel;

grouping the pixels in the window into a first pixel group having a higher brightness component than the mean and a second pixel group having a lower brightness component than the mean; and

determining a difference between a first sub-mean of brightness components of pixels belonging to the first pixel group and a second sub-mean of brightness components of pixels belonging to the second pixel group as the bimodality of the concerned pixel.

5. The digital image quality enhancing method of claim 1, wherein the updating of the history information comprises:

determining whether the concerned pixel is a background pixel or an image pixel using brightness and saturation components of the concerned pixel and whether the concerned pixel is a halftone pixel using the brightness component and a connection component;

when the concerned pixel is determined as the background pixel, updating first history information by storing the concerned pixel and a number of background pixels that successively appear above the concerned pixel as the first history information of the concerned pixel; and

when the concerned pixel is determined as the image pixel, updating second history information by storing the concerned pixel and a number of image pixels that successively appear above the concerned pixel as the second history information of the concerned pixel.

6. The digital image quality enhancing method of claim 5, wherein the determination of the pixel type comprises:

when the brightness component of the concerned is greater than a high brightness threshold and the saturation component of the concerned pixel is less than a saturation threshold, classifying the concerned pixel as the background pixel;

when the brightness component of the concerned pixel is greater than a low brightness threshold and less than the high brightness threshold or the saturation component of the concerned pixel is greater than the saturation threshold, classifying the concerned pixel as the image pixel; and

obtaining a difference between the connection component and the brightness component in the window of a predetermined size around the concerned pixel and classifying the concerned pixel as the halftone pixel using the connection component, the

brightness component, and the obtained difference between the connection component and the brightness component.

7. The digital image quality enhancing method of claim 6, wherein the classification of the concerned pixel as the halftone pixel comprises:

- obtaining the connection component of pixels in a window;
- comparing a difference between a maximum value and a minimum value of brightness components of the pixels in the window with a brightness difference threshold;
- and
- when the connection component is greater than a predetermined value and the difference is greater than the brightness difference threshold, determining the concerned pixel as the halftone pixel.

8. The digital image quality enhancing method of claim 7, wherein the obtaining of the connection component comprises:

- binarizing the pixels in the window using the brightness component; and
- obtaining the connection component according to different methods based on a binary value allocated to the concerned pixel as the binarization result.

9. The digital image quality enhancing method of claim 8, wherein the binarizing of the pixels comprises:

- calculating a mean of the brightness components of all the pixels in the window; and
- comparing the mean with each of the brightness components of all of the pixels to perform the binarization based on the comparison result.

10. The digital image quality enhancing method of claim 9, wherein the obtaining of the connection component comprises:

- when the brightness components of the concerned pixel are greater than the mean, counting the number of blocks comprising pixels that successively appear clockwise and have different binary values from a binary value of the concerned pixel to determine the counted number as the connection component.

11. The digital image quality enhancing method of claim 10, wherein the obtaining of the connection component comprises:

when the brightness component of the concerned pixel is less than the mean, determining the connection component according to different methods based on a magnitude of a sum of binary values of pixels located in four directions from the concerned pixel.

12. The digital image quality enhancing method of claim 5, wherein the updating of the first history information comprises:

setting a first number  $m$  to determine the background block feature when the number of background pixels that successively appear above the concerned pixel is greater than the first number  $m$ ;

storing the first number  $m$  as the first history information; and

when the number of background pixels is less than the first number  $m$ , storing a corresponding number of background pixels as the first history information.

13. The digital image quality enhancing method of claim 5, wherein the updating of the second history information comprises:

setting a first number  $p$  to determine the image block feature when the number of image pixels that successively appear above the concerned pixel is greater than the first number  $p$ ;

storing the first number  $p$  as the second history information; and

when the number of image pixels is less than the first number  $p$ , storing a corresponding number of image pixels as the second history information.

14. The digital image quality enhancing method of claim 1, wherein the determining of the block feature type comprises:

when a first number of  $m$  pixels, from which a background block feature type is to be detected, successively appear by a second number of  $n$ , from which the background block feature is to be detected, in left and right directions of the concerned pixel, classifying the concerned pixel as a pixel having the background block feature type with reference to the history information;

when a third number of  $p$  pixels, from which an image block feature type is to be detected, successively appear by a fourth number of  $q$  pixels, from which the image block feature type is to be detected, in the left and right directions of the concerned pixel, classifying the concerned pixel as a pixel having the image block feature type; and

classifying the concerned pixel as a pixel having a halftone block feature type using the pixel type of the concerned pixel, pixel types of pixels in the left direction of the concerned pixel, and the third type of the third area to which the neighboring pixel above the concerned pixel belongs.

15. The digital image quality enhancing method of claim 14, wherein the classifying of the concerned pixel as the pixel having the halftone block feature type comprises:

when the concerned pixel is a halftone pixel, determining whether the halftone pixel exists within a halftone distance threshold in the left direction of the concerned pixel;

when the concerned pixel is the halftone pixel, determining whether the third area to which the second neighboring pixel above the concerned pixel belongs is the halftone image area; and

when the concerned pixel satisfies one of the two determination requirements, classifying the concerned pixel as a pixel having the halftone block feature.

16. The digital image quality enhancing method of claim 14, wherein the determining of the block feature type further comprises:

setting a first position following a second position from which the background block feature type is finally detected in the left direction of the concerned pixel to be 1 in an image mark memory when the image block feature type is detected from the concerned pixel in the classification of the concerned pixel as the pixel having the image block feature.

17. The digital image quality enhancing method of claim 1, wherein the determining of the area type comprises:

when the second area to which the first neighboring pixel in the left direction of the concerned pixel belongs is a background area, determining the area to which the concerned pixel belongs as one of a text area and the background area depending on the pixel type of the concerned pixel;

when the second area to which the first neighboring pixel in the left direction of the concerned pixel belongs is the text area, determining the area to which the concerned pixel belongs as one of the background area, a continuous tone image area, and the text area depending on the block feature type of the concerned pixel and the third type of the third area to which the second neighboring pixel above the concerned pixel belongs;

when the second area to which the first neighboring pixel in the left direction of the concerned pixel belongs is the continuous tone image area, determining the area to which the concerned pixel belongs as one of the background area, the halftone image area, and the continuous tone image area depending on the block feature type of the concerned pixel; and

when the second area to which the first neighboring pixel in the left direction of the concerned pixel belongs is the halftone image area, determining the area to which the concerned pixel belongs as one of the halftone image area and the continuous tone image area based on the pixel type of the concerned pixel.

18. The digital image quality enhancing method of claim 17, wherein the determining of the concerned pixel as one of the text area and the background area comprises:

determining whether the concerned pixel is the background pixel when the concerned pixel is the background pixel;

determining the area to which the concerned pixel belongs as the background area; and

when the concerned pixel is not the background pixel, determining the area to which the concerned pixel belongs as the text area.

19. The digital image quality enhancing method of claim 17, wherein the determining of the area of the concerned pixel as one of the background area, the continuous tone image area, and the text area comprises:

when the concerned pixel has the background block feature, classifying the concerned pixel into the background area;

when the concerned pixel has the image block feature or the image mark memory for a previous line is set to be 1, classifying the concerned pixel into the continuous tone image area;

when the area to which the neighboring pixel above the concerned pixel belongs is one of the continuous tone image area and the halftone image area, classifying the concerned pixel into the continuous tone image area; and

when the concerned pixel does not satisfy any one of the above requirements for determining the type of the area to which the concerned pixel belongs, determining the area to which the concerned pixel belongs as the text area.

20. The digital image quality enhancing method of claim 17, wherein the determining of the area of the concerned pixel as one of the background area, the halftone image area, and the continuous tone image area comprises:

when the concerned pixel has the background block feature, classifying the concerned pixel into the background area;

when the concerned pixel has the halftone block feature, classifying the concerned pixel into the halftone image area; and

when the concerned pixel has neither the background block feature nor the halftone block feature, determining the area to which the concerned pixel belongs as the continuous tone image area.

21. The digital image quality enhancing method of claim 17, wherein the determining of the area of the concerned pixel as one of the halftone image area and the continuous tone image area comprises:

determining whether the concerned pixel is the halftone pixel when the concerned pixel is the halftone pixel;

determining the area to which the concerned pixel belongs as the halftone image area; and

when the concerned pixel is not the halftone pixel, determining the area to which the concerned pixel belongs as the continuous tone image area.

22. The digital image quality enhancing method of claim 1, wherein the performing of the different image enhancing processes comprises:

when the area to which the concerned pixel belongs is determined as the text area in the determination of the area type of the concerned pixel, performing one of white-filling, black-filling, and unsharpened masking using a first emphasis coefficient on the concerned pixel according to the magnitude of the brightness component of the concerned pixel;

when the area to which the concerned pixel belongs is determined as the continuous tone image area in the determination of the area type of the concerned pixel, performing unsharpened masking using a second emphasis coefficient on the concerned pixel;

when the area to which the concerned pixel belongs is determined as the halftone image area in the determination of the area type of the concerned pixel, performing one of

non-processing, low-pass filtering, and unsharpened masking using a third emphasis coefficient on the concerned pixel; and

when the area to which the concerned pixel belongs is determined as the background area in the determination of the area type of the concerned pixel, outputting the concerned pixel as it is.

23. The digital image quality enhancing method of claim 22, wherein the first and second emphasis coefficients are calculated using a mean brightness of pixels in a predetermined window including the concerned pixel.

24. A computer-readable recording medium encoded with data readable by a computer to implement a method of improving a quality of a document image comprising pixels with a predetermined resolution and obtained by scanning a script comprising a combination of a background, a text, and an image, the method comprising:

updating history information regarding color data and a pixel type of a concerned pixel using previous history information of the concerned pixel;

determining a block feature type of the concerned pixel using the pixel type and the updated history information of the concerned pixel;

determining a type of an area to which the concerned pixel belongs based on a second type of a second area to which a first neighboring pixel in a left direction of the concerned pixel belongs, a third type of a third area to which a second neighboring pixel in a line above the concerned pixel belongs, the pixel type of the concerned pixel, and the determined block feature type; and

performing different image quality enhancing processes on the concerned pixel based on the determined area type.

25. A digital image quality improving apparatus to improve a quality of a document image comprising pixels with a predetermined resolution and obtained by scanning a script comprising a combination of a background, a text, and an image, the apparatus comprising:

a history information updating unit that updates history information regarding color data and a pixel type of a concerned pixel using previous history information of the concerned pixel;



a block feature type detecting unit that determines a block feature type of the concerned pixel using the pixel type and updated history information of the concerned pixel;

an area type determining unit that determines a type of an area to which the concerned pixel belongs depending on a type of an area to which a neighboring pixel in a left direction of the concerned pixel belongs, the pixel type of the concerned pixel, a type of an area to which a neighboring pixel in a line above the concerned pixel belongs, and the block feature type of the concerned pixel provided by the block feature type detecting unit; and

an image quality enhancing unit that enhances an image quality of the concerned pixel to different degrees according to the area type determined by the area type determining unit.

26. The digital image quality enhancing apparatus of claim 25, further comprising a storing unit that comprises a line memory having a width of 1 bit, and when the block feature type detecting unit detects an image block feature from the concerned pixel, sets a position next to a position from which a background block feature is finally detected in the left direction of the concerned pixel to be 1, and stores the value of 1 in the line memory, wherein the area type determining unit uses the value of the line memory as information to determine the area type.

27. The digital image quality enhancing apparatus of claim 25, wherein the block feature type detecting unit comprises:

a background block feature detecting unit that classifies the concerned pixel as a pixel having the background block feature with reference to the history information when blocks of first sizes in left and upper directions of the concerned pixel comprise background pixels;

an image block feature detecting unit that classifies the concerned pixel as a pixel having the image block feature with reference to the history information when blocks of second sizes in the left and upper directions of the concerned pixel comprise image pixels; and

a halftone block feature detecting unit that classifies the concerned pixel as a pixel having a halftone block feature using the pixel type of the concerned pixel, pixel types of pixels in the left direction of the concerned pixel, and a type of an area to which a neighboring pixel above the concerned pixel belongs.

28. A method of enhancing digital image quality of a document image comprising pixels with a predetermined resolution, the method comprising:

- converting color data of a concerned pixel;
- updating history information according to a pixel type of the concerned pixel;
- determining a block feature type of the concerned pixel;
- determining a type of an area to which the concerned pixel belongs; and
- enhancing image quality of each determined type of area.

29. The method of claim 28, wherein the updating of history information according to the pixel type is performed by using previous history information of the concerned pixel.

30. The method of claim 28, wherein the determining of the block feature type is performed using the type and updated history information of the concerned pixel.

31. The method of claim 28, wherein the determining a type of an area to which the concerned pixel belongs is performed based on a type of an area to which a neighboring pixel in a left direction of the concerned pixel belongs, a type of an area to which a neighboring pixel in a line above the concerned pixel belongs, the pixel type of the concerned pixel, and the determined block feature type.

32. The method of claim 29, wherein the updating of history information comprises low-pass filtering (pre-processing) the concerned pixel according to a magnitude of a bimodality of the concerned pixel.

33. A digital image quality improving apparatus to improve a quality of a document image comprising pixels with a predetermined resolution and obtained by scanning a script comprising a combination of a background, a text, and an image, the apparatus comprising:

- a history information updating unit that updates history information according to a pixel type of a concerned pixel;
- a block feature type detecting unit that determines a block feature type of the concerned pixel;
- an area type determining unit that determines a type of an area to which the concerned pixel belongs; and

an image quality enhancing unit that enhances an image quality of the concerned pixel to different degrees according to the area type determined by the area type determining unit.

34. The apparatus of claim 33, wherein the history information updating unit updates history information regarding color data and the pixel type of the concerned pixel using previous history information of the concerned pixel.

35. The apparatus of claim 33, wherein the block feature type detecting unit determines the block feature type of the concerned pixel using the pixel type and updated history information of the concerned pixel.

36. The apparatus of claim 33, wherein the area type determining unit determines the type of an area to which the concerned pixel belongs depending on a type of an area to which a neighboring pixel in a left direction of the concerned pixel belongs, the pixel type of the concerned pixel, a type of an area to which a neighboring pixel in a line above the concerned pixel belongs, and the block feature type of the concerned pixel provided by the block feature type detecting unit.

37. The apparatus of claim 33, wherein the image quality enhancing unit enhances the image quality of the concerned pixel to different degrees according to the area type determined by the area type determining unit.

38. The digital image quality enhancing apparatus of claim 33, further comprising a storing unit that comprises a line memory having a width of 1 bit, and when the block feature type detecting unit detects an image block feature from the concerned pixel, sets a position next to a position from which a background block feature is finally detected in the left direction of the concerned pixel to be 1, and stores the value of 1 in the line memory, wherein the area type determining unit uses the value of the line memory as information to determine the area type.

39. The digital image quality enhancing apparatus of claim 33, wherein the block feature type detecting unit comprises:

a background block feature detecting unit that classifies the concerned pixel as a pixel having the background block feature with reference to the history information when blocks of first sizes in left and upper directions of the concerned pixel comprise background pixels;

an image block feature detecting unit that classifies the concerned pixel as a pixel having the image block feature with reference to the history information when blocks of second sizes in the left and upper directions of the concerned pixel comprise image pixels; and

a halftone block feature detecting unit that classifies the concerned pixel as a pixel having a halftone block feature using the pixel type of the concerned pixel, pixel types of pixels in the left direction of the concerned pixel, and a type of an area to which a neighboring pixel above the concerned pixel belongs.

40. A recording medium encoded with data readable by a computer to implement a method of improving a quality of a document image comprising pixels with a predetermined resolution and obtained by scanning a script comprising a combination of a background, a text, and an image, the method comprising:

- converting color data of a concerned pixel;
- updating history information according to a pixel type of the concerned pixel;
- determining a block feature type of the concerned pixel;
- determining a type of an area to which the concerned pixel belongs; and
- enhancing image quality of each determined type of area.

41. A digital image quality improving apparatus, comprising:

- a determining unit reclassifying a pixel type, a block feature type, and an area type of a concerned pixel of an image pixel by pixel; and

- an image quality enhancement unit performing one of different processes based on the pixel type, the block feature type, and the area type.

42. The apparatus of claim 41, wherein the determining unit determines the area type of the concerned pixel based on a first neighboring pixel of the concerned pixel, a second neighboring pixel of the concern pixel, and the block feature type of the concerned pixel.

43. The apparatus of claim 41, wherein the first neighboring pixel is disposed in a direction of the concerned pixel.
44. The apparatus of claim 41, wherein the second neighboring pixel is disposed above the concerned pixel.
45. The apparatus of claim 41, wherein the block feature type of the concerned pixel comprises one of a background block feature type, an image block feature type, and a halftone block feature.
46. The apparatus of claim 41, wherein the digital image is reclassified and enhanced pixel-by-pixel.
47. A digital image quality improving apparatus, comprising:  
a determining unit reclassifying a pixel type, a block feature type, and an area type of a concerned pixel of an image;  
an image quality enhancement unit performing one of different processes based on the pixel type, the block feature type, and the area type; and  
an incrementing unit to continuously increment the concerned pixel to a next pixel of the image such that each pixel of the image is reclassified and enhanced.